



## Changes in soft tissue profile following the treatment using a Herbst appliance – A photographic analysis

### Promena mekotkivnog profila posle terapije Herbst aparatom – analiza fotografija

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#### Abstract

**Background/Aim.** Aesthetics is the reason for most of the class II malocclusion patients to opt for orthodontic treatment. In order to regulate retrognathic profile Herbst appliance for anterior movement of the mandible can be a treatment of choice. The aim of this study was to determine the soft tissue profile changes following Herbst appliance therapy on before and after treatment photos, using the computer program. **Methods.** This investigation was performed on profile photographs of 20 class II patients (12 females and 8 males) aged 18–23 years. Analysis of the changes in soft tissue facial structure relationships evident on the photographs before and after the Herbst appliance therapy was performed using Bentley Micro Station program. The first contour of the soft tissue profile was marked. The following reference lines were subsequently traced: Ricketts aesthetic E line and Juanita line. The area enclosed by these two lines included the nose, upper and lower lip, chin and free space in front of the lips. Using the computer program, the surfaces of the soft tissue structures and free space defined by the reference lines and profile contours were measured. Calculation of the relative proportion of surfaces was done for each photograph. The data obtained were then compared for each patient before and

after the treatment. Skeletal and dentoalveolar treatment effects that support soft tissue changes were presented by the profile cephalometric parameters of sagittal occlusion (SO) analysis. **Results.** A reduction in the relative surface of the upper lip in males ( $p < 0.01$ ) and females ( $p < 0.05$ ) was shown by the pictures. The space occupied by the chin was reduced after the treatment for females only ( $p < 0.05$ ). The relative surface of the nasal soft tissues, that was included in the reference space was increased ( $p < 0.01$ ) in both genders. The relationship between the soft tissue and empty surface was changed in favor of the empty surface ( $p < 0.05$ ) in females. No statistically significant differences were found between the males and the females, before or after the Herbst appliance therapy. The soft tissue changes were the consequence of skeletal and dentoalveolar treatment effects: upper incisors retrusion, lower incisor protrusion and forward movement of the lower jaw. **Conclusions.** The Herbst appliance therapy caused a significant improvement of the profile appearance. The extent of soft tissue changes that occur on its dentoalveolar and skeletal support is a complex issue.

**Key words:** malocclusion, angle class II; orthodontics, corrective; photography; anthropometry; face.

#### Apstrakt

**Uvod/Cilj.** Većina mladih sa malokluzijom klase II odlučuje se za ortodontski tretman iz estetskih razloga. Za ispravljanje retrognatog profila može se koristiti aparat za anteriorno pomeranje mandibule – Herbst aparat. Cilj istraživanja bio je da se utvrde promene mekotkivnog profila posle primene Herbst aparata. **Metode.** Ispitivanje je izvršeno na profilnim fotografijama 20 mladih ljudi (12 ženskog i 8 muškog pola) sa malokluzijom klase II, starosti od 18 do 23 godine. Analizirane su promene odnosa mekotkivnih struktura lica na fotografijama načinjenim pre i posle sprovedene terapije Herbst aparatom. Za tu analizu korišćen je Bentley Micro Station program. Digitalizovana je granica

kontura mekotkivnog profila i ucrtavane su referentne linije: Ricketts-ova estetska E linija i Juanita linija. Ove linije ograničavaju prostor u kome su smešteni nos, gornja i donja usna i brada, kao i slobodni prostor koji se nalazi ispred konture mekotkivnog profila. Kompiuterski su merene površine mekotkivnih struktura i slobodnog prostora definisane referentnim linijama i konturom profila. Unutar slike izračunati su relativni odnosi površina. Nakon toga dobijeni podaci su poređeni pre i posle terapije za svaku osobu. Skeletni i dentoalveolarni terapijski efekti koji prouzrokuju mekotkivne promene prikazani su analizom sagitalne okluzije (SO) profilnog telerendgena. **Rezultati.** Sprovedenim merenjima utvrđeno je da je došlo do smanjenja relativne površine gornje usne kako kod dečaka ( $p < 0,01$ ), tako i kod devojčica

( $p < 0,05$ ). Prostor koji zauzima brada posle terapije značajno se smanjio samo kod devojčica ( $p < 0,05$ ). Relativna površina mekotkivnog profila nosa obuhvaćena referentnim prostorom povećana je sa podjednakom statističkom značajnošću od  $p < 0,01$  kod oba pola. Odnos mekog tkiva i praznog prostora promenio se u korist praznog prostora ( $p < 0,05$ ) kod devojčica. Nije bilo statistički značajne razlike između dečaka i devojčica pre i posle sprovedene terapije. Retruzija gornjih i protruzija donjih sekutića, kao i mezijalno

pomeranje donje vilice glavni su terapijski efekti koji izazivaju mekotkivne promene donje trećine lica. **Zaključak.** Terapija Herbst aparatom dovodi do značajnog poboljšanja izgleda profila lica. Prilagodljivost mekog tkiva na promene njegove koštane i dentoalveolarne potpore je kompleksna.

**Ključne reči:**  
**malokluzija, klase II; ortodontija, korektivna; fotografija; antropometrija; lice.**

## Introduction

Aesthetics is one of the main reasons for most of the patients with class II malocclusion, especially teenagers, to opt for orthodontic therapy expecting it to improve their features and thereby improve their self-confidence and acceptance amongst their peers<sup>1-3</sup>. In order to regulate retrognathic profile an appliance for anterior movement of the mandible, known as Herbst appliance (Bite Jumping Hinge appliance), can be the treatment of choice. Skeletal retrusion is characterized by convex profile that disturbs the facial appearance of a patient. It is considered that the morphology of the maxilla, mandible as well as the shape of the teeth has an indirect effect on the appearance of the face<sup>4</sup>. The appliance constantly holds the mandible in a protruded position and due to this activates the masticatory muscles.

It has been proved that compared to removable appliances fixed functional appliances can stimulate growth of the mandible and have a tendency to instigate horizontal growth of the condyle<sup>5</sup>. It also causes dentoalveolar changes, such as protrusion of mandibular incisors and retrusion of maxillary incisors which can have an effect on lip profile<sup>6</sup>.

Many studies have shown that for the majority of cases the changes in soft tissue structures are not followed by the changes in hard tissues<sup>7,8</sup>. However, changes in soft tissue structures represent a crucial parameter for evaluating the aesthetics following treatment. Most scientific papers on the effect of therapy with functional appliances emphasize the skeletal and dental changes, while only a few study the effects of treatment on the soft tissues<sup>6</sup>. There is a lack of long-term studies about the effects of Herbst appliance treatment while a clinical significance of soft tissue changes has been questioned<sup>6</sup>. In order to quantify soft tissue profiles and emphasize the importance of soft tissue profile assessment Skinazi et al.<sup>9</sup> measured the actual and relative size of the facial profile component parts instead of the common usage of the relationship between surface landmarks.

The aim of this study was to determine the soft tissue profile changes of class II cases following Herbst appliance therapy on pre- and aftertreatment photos, using the computer program and the present main skeletal and dentoalveolar treatment effects.

## Methods

After Ethics committee approval and signing information consent the study was performed using profile photos

taken before and after the treatment of patients with class II malocclusions using Herbst appliances at the Clinic of Orthodontics, Faculty of Dentistry, University of Belgrade.

All photographs were taken under standardized conditions (distance and position) with the same digital photo camera (Canon Power Shot G6). The distance was of 1.2 m and patients were sitting in the upright position with their heads stabilized in order to achieve the same position when taking photos before and after the treatment.

A total of 20 patients of both genders, average 20 years of age participated in this study (12 females from 18 to 22.5 years, and 8 males from 18.5 to 23 years). Skeletal maturity was first determined for each patient according to the stages of the cervical vertebral maturation. All of the patients indicated the stage of maximal growth, so the sample consisted of nongrowing patients.

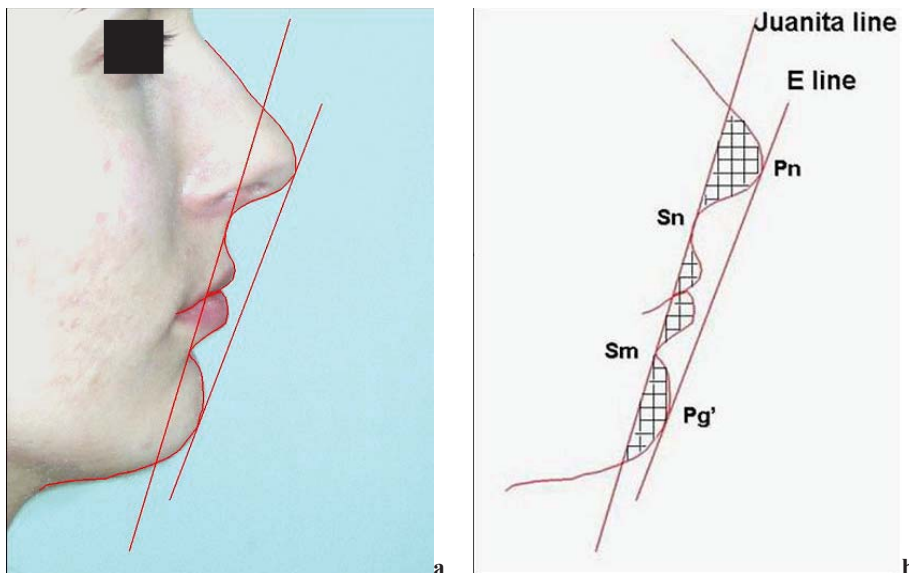
Analysis of the changes in soft tissue facial structure relationships evident on the photographs before and after the Herbst appliance therapy was performed using Bentley Micro Station program. This program was used for the measurement of confined surfaces. I/RAS C (Intergraph) program was used to enter the digital photographs into the Bentley Micro Station program.

Bentley Micro Station program helped in marking the contour of the soft tissue profile. The following reference lines according to Skinazi et al.<sup>9</sup> were subsequently traced: Ricketts aesthetic E-passing through the soft tissue pogonion (Pg') and the pronazale (Pn) points; Juanita line passing through the subnasal (Sn) and supramentale (Sm) points<sup>9</sup> (Figure 1).

These points were used only for the purpose of defining the space within which the soft tissue structures were analyzed using measurements of relative surfaces.

The area enclosed by these two lines included the nose, upper and lower lip, chin and free space in front of the lips. Using the functions of the Micro Station program, the surfaces of the soft tissue structures and free space, defined by the reference lines and profile contours were measured. Calculation of the relative proportion of surfaces was performed for each photo. The data obtained were compared for each patient before and after the treatment.

All of the class II patients were treated successfully (class I molar relationship, normal overjet and overbite) at the end of the treatment. The therapy with the Herbst appliance and its effects were considered as combined, because the Herbst appliance was used in combination with the multibracket appliance (Figure 2). The Herbst appliance was



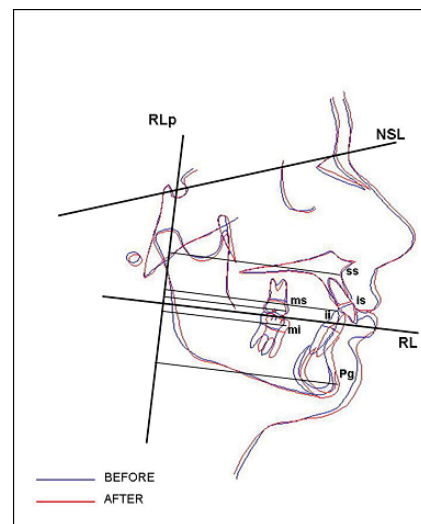
**Fig. 1a – Juanita line, Ricketts aesthetic E line; b) the area enclosed by these two lines (nose, upper and lower lip, chin and free space in front of the lips).**

removed after 6–8 months and then the multibracket fixed appliance was used, so the mean overall treatment time was 17 months. All of the patients were in the retention period. Recall visit for reevaluation of the treatment outcome was appointed in two years.



**Fig. 2 – The cemented Herbst appliance and the attached fixed multibracket appliance on the frontal teeth.**

Soft tissue changes caused by the Herbst appliance are the consequence of skeletal and dentoalveolar changes. In order to facilitate understanding this relation, it is necessary to present profile cephalometric parameters. SO analysis by Panchez and Anebus-Panchez<sup>4</sup> showed main sagittal skeletal and dentoalveolar changes. The pretreatment and posttreatment cephalometric images were first superimposed, in relation to the nasion-sella line (NSL), and, then, the maxillary occlusal plane – RL (occlusal reference line passing through the incisal edge of the upper incisor and the most distal point of molar contact in the occlusion) was determined. A line perpendicular to the RL through the sella (point S), *ie* RLP was used in measurements (Figure 3). Lin-



**Fig. 3 – Superimposition of cephalometric images before (blue) and after (red) the treatment with visible skeletal, dentoalveolar and soft tissue changes.**

ear measurements were performed parallelly with RL to RLP for each patient and selected in SO analysis (analysis of changes in sagittal occlusion), through the following parameters: ms-RLp – position of the first permanent maxillary molar (the shortest distance of the most mesial point of the approximal surface of the first upper molar to RLP); mi-RLp – position of the first permanent mandibular molar (the shortest distance of the most mesial point of the approximal surface of the lower first molar to RLP); (ms-RLp) – (mi-RLp) the molar relationship correction; is-RLp – position of the central maxillary incisor (the shortest distance of the incisal edge of the upper incisor to RLP); ii-RLp – position of the central mandibular incisor (the shortest distance of the incisal edge of the lower incisor to RLP); (is-RLp) – (ii-RLp) the overjet correction; ss-RLp – position of the maxilar base (the shortest distance of the most recessed point of the anterior side of the maxilla to RLP); Pg-RLp – position of the mandibular base

(the shortest distance of the most prominent point of the chin profile to RLp); (ss-RLp) – (Pg-RLp) the skeletal correction.

The results were statistically analyzed, using Microsoft Office Excel 2007. The used standard statistical analyses were: measures of central tendency – mean, measures of variability – standard deviation (SD), and statistical significance (*p*) of the obtained differences were shown by the Student's paired *t*-test.

**Results**

Table 1 shows the values of statistical reduction in the relative surface of the upper lip in the males (*p* < 0.01) and

tistically significantly reduced after the treatment for the females only (*p* < 0.05). The nasal soft tissues relative surface, included in the reference space was statistically significantly increased (*p* < 0.01) in both genders. The relationship between the soft tissue and empty surface was changed in favor of the empty surface, and it was statistically significant (*p* < 0.05) in the females (Table 2). *T*-tests showed no statistically significant differences between the males and the females, before or after the Herbst appliance therapy.

Main skeletal and dentoalveolar treatment changes are shown in Table 3, and Figure 5 and 6. The first permanent maxillary molar was distalized, whereas the first mandibular molar showed mesial position. Molar relation correction

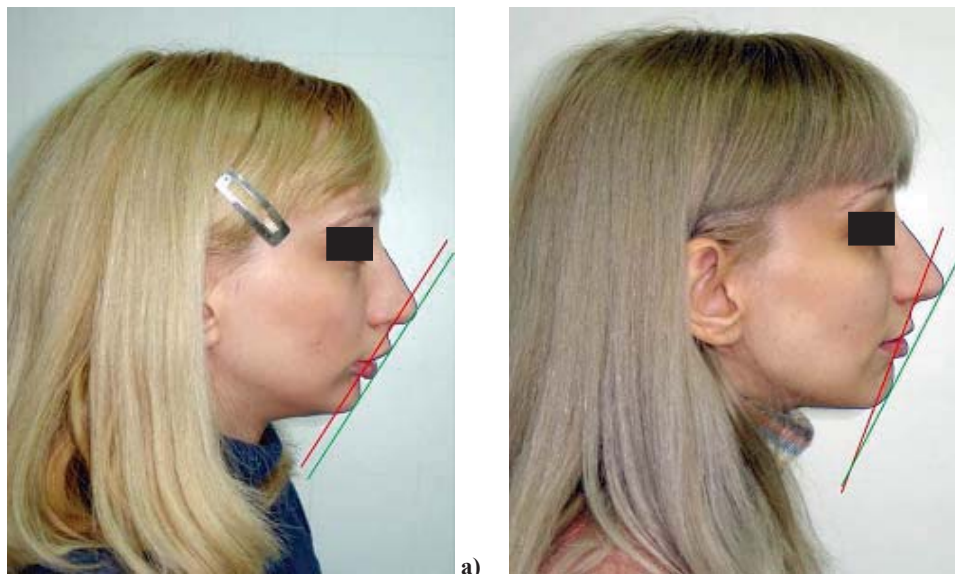
**Table 1**  
Distribution of the values before and after the Herbst treatment of class II cases for the percentage contribution of profile structures and the free space between the Ricketts and Juanita lines

Profile structures	Males (n = 8)			Females (n = 12)			<i>t</i> -test (males/females)	
	before (%) ( $\bar{x} \pm SD$ )	after (%) ( $\bar{x} \pm SD$ )	<i>t</i> -test	before (%) ( $\bar{x} \pm SD$ )	after (%) ( $\bar{x} \pm SD$ )	<i>t</i> -test	before	after
Nose	35.54 ± 9.13	50.45 ± 10.03	<i>p</i> < 0.01*	37.12 ± 8.64	50.76 ± 11.14	<i>p</i> < 0.01*	<i>p</i> = 0.704	<i>p</i> = 0.952
Upper lip	18.4 ± 4.28	11.36 ± 4.06	<i>p</i> < 0.01*	15.6 ± 3.77	11.19 ± 3.82	<i>p</i> < 0.05*	<i>p</i> = 0.149	<i>p</i> = 0.952
Lower lip	12.59 ± 4.41	13.54 ± 5.08	<i>p</i> = 0.697	12.32 ± 5.64	12.79 ± 3.28	<i>p</i> = 0.814	<i>p</i> = 0.912	<i>p</i> = 0.701
Chin	33.47 ± 11.50	24.65 ± 9.02	<i>p</i> = 0.110	34.95 ± 8.03	25.26 ± 8.12	<i>p</i> < 0.05*	<i>p</i> = 0.745	<i>p</i> = 0.878

\*statistically significant

the females (*p* < 0.05). The relative surface of the lower lip was increased, but with no statistical significance in both genders (Figure 4). The space occupied by the chin was sta-

during the Herbst treatment was over 4 mm. The maxillary incisors showed retroinclination, whereas the mandibular ones showed proclination. Overjet correction during the treatment



**Fig. 4 – Before (a) and after (b) the treatment with Herbst appliance (the area between the Juanita - red and the Ricketts aesthetic E lines – green).**

**Table 2**  
The relative ratio of the surfaces filled with soft tissue structures of the profile and the empty space before and after the Herbst treatment of class II cases between the Ricketts and Juanita lines

Time related to the Herbst treatment	Soft tissue: free space ratio ( $\bar{x} \pm SD$ )		<i>t</i> -test
	male	female	
Before	1.73 ± 0.53	1.42 ± 0.28	<i>p</i> = 0.124
After	1.35 ± 0.31	1.21 ± 0.13	<i>p</i> = 0.190
<i>t</i> -test	<i>p</i> = 0.109	<i>p</i> < 0.05*	

\*statistically significant



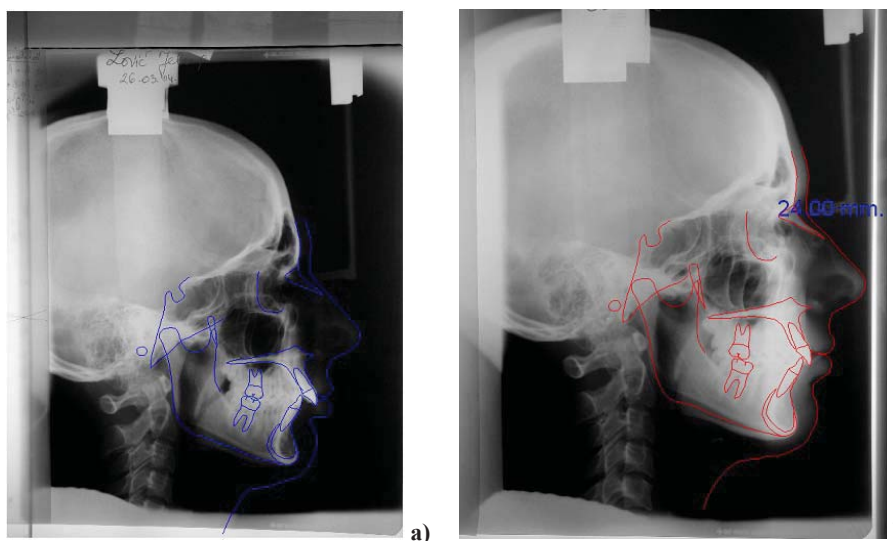
**Table 3**  
**Analysis of sagittal skeletal and occlusal changes before and after the treatment ( $\bar{x} \pm SD$ ) – sagittal occlusion (SO) analysis by Pancherz**

SO analysis	Variable (measurements to RLP in mm)	Before	After	After – Before (D)	Correction Maxilla+ Mandible
Skeletal + Dental	ms	64.35 ± 2.31	62.37 ± 2.27	1.98 ± 2.40	Molar relation
Skeletal + Dental	mi	62.05 ± 2.51	64.38 ± 2.35	2.33 ± 0.73	4.31 ± 0.52
Skeletal + Dental	is	94.45 ± 2.81	91.41 ± 2.72	3.04 ± 1.35	Overjet
Skeletal + Dental	ii	84.30 ± 2.65	88.23 ± 2.81	3.93 ± 1.32	6.97 ± 1.40
Skeletal + Dental	ss	83.14 ± 2.26	82.36 ± 2.07	0.78 ± 0.66	Skeletal correct.
	Pg	87.40 ± 2.86	88.44 ± 2.43	1.04 ± 1.21	1.82 ± 0.89
Dental (molars)	ms(D)-ss(D)	–	–	1.20 ± 0.51	Molars
	mi(D)-Pg(D)	–	–	1.29 ± 0.94	2.49 ± 0.87
Dental (incisors)	is(D)-ss(D)	–	–	2.26 ± 1.06	Incisors
	ii(D)-Pg(D)	–	–	2.89 ± 1.04	5.15 ± 1.83

RLP – occlusal reference line perpendicular; ms – the most mesial point of the approximal surface of the first upper molar; mi – the most mesial point of the approximal surface of the lower first molar; is – incisal edge of the upper incisor; ii – incisal edge of the lower incisor; ss – the most recessed point of the anterior side of the maxilla; Pg – the most prominent point of the skeletal chin profile.



**Fig. 5 – Computer drawings of anatomical details superimposition over the patient’s photo profile: a) before the treatment; b) after the treatment.**



**Fig. 6 – Profile cephalogram with computer-drawn anatomical details: a) before treatment; b) after the treatment.**

was almost 7 mm. The point *ss* changed its position slightly backward, while the point *Pg* changed its position anteriorly. Skeletal correction during the Herbst treatment was almost 2 mm.

### Discussion

Advances in imaging are likely to enhance the accuracy and reliability of orthodontic diagnosis and treatment planning, and will be of importance in both clinical practice and research<sup>10</sup>.

Herbst appliance therapy stimulates the growth of the mandible both by increasing the gonial angle and the growth of the condyle<sup>11-15</sup>. Skeletal and soft tissue facial profile convexity was reduced in adults and adolescents as a result of treatment by the Herbst appliance<sup>16</sup>.

Examining the effects of the Herbst appliance in young adults with class II, division 1 malocclusion, Ruf and Pancherz<sup>16</sup> found that the same soft tissue changes occurred as in Herbst treatment in adolescent patients. The improvement of facial profile is combined with the upper lip retrusion but not with changes in the lower lip position. They state that both lips are supported by the upper incisors, thus significantly participating in the anteroposterior position of the upper lip in particular, while the lower incisors have no significant effect on the position of the lower lip. Flores-Mir et al.<sup>6</sup> found no difference in the effect of Herbst treatment on the soft tissue profile between adolescents and young adults, too. However, they point out that facial esthetic is generally improved and more detailed assessment of facial esthetics should be made after the examination of the patient's front face during conversation, function, individual facial expression and smile.

During Herbst appliance therapy anterior movement of the lower jaw occurs and the supramentale point also moves forward. The results obtained by this study show a change in slope of the Juanita line, which then rotates around the subnasal point. This is the reason for the surfaces of the soft tissues beyond the subnasal point to cover less of the reference space following the therapy, while the surfaces above this point cover more space. The movement of the lower jaw also brings about a forward shift of the pogonion point, so that the E line rotates around the tip of the nose. This change increases the surface of the free space within the reference space. Former studies based on profile cephalograms analysis of the same patients, show skeletal and dentoalveolar changes that supporting facial soft tissue change too<sup>17-19</sup>. Skeletal and dentoalveolar treatment changes in this study indicate the essential details. Upper incisors retrusion, lower incisor protrusion and forward movement of the lower jaw affect overjet reduction. It is the most important consequence to the correction and straightening of the lower facial third soft tissue.

Changes produced by fixed functional appliances seem to restrict forward movement of the upper lip<sup>6</sup>. A relative surface reduction of the upper lip is the consequence of a number of factors. Most patients targeted for Herbst appliance therapy have class II malocclusions, hence the reduc-

tion in the surface of the upper lip is caused by upper incisors, retrusion as well as maxillary growth inhibition<sup>11, 12, 20</sup>. In most cases, SNA angle reduction also occurs. Some authors cite that there is a reduction in upper lip prominence with no a change in inclination of the upper lip<sup>21</sup>. They explain this using similar type of movements of subnasale and labiale superior points. As explained earlier, Juanita line slope influences the reduction of the surface occupies by the upper lip. It is most probable that these changes are the result of a combination of skeletal and dentoalveolar changes<sup>22-26</sup>.

Changes caused by fixed functional appliances seem to limit upper lip forward movement<sup>6</sup>. The relative surface of the upper lip increases due to lower lip forward movement. Mandibular advancement by the mandibular protraction appliance (MPA) similar to the Herbst appliance produces satisfactory results by reducing facial convexity. The treatment effect of this appliance is the correction of malocclusion through mesial displacement of the first mandibular molars, with the consequent protrusion of the lower lip<sup>27</sup>. The lower lip also moves forward because of lower lip position changes. As for the soft tissue, a significant forward movement of the pogonion (*Pg'*) was found in the treatment group compared with the controls. Our findings are supported by the authors who state that the fixed functional Jasper Jumper appliance (similar to the Herbst appliance) promotes horizontal growth at the pogonion area and that the overlying soft tissue reflects that change<sup>28</sup>. The increase in the lower lip surface reported in this study was not statistically significant, which can be explained by the slope of the Juanita line and by straightening of the inferiorly curved lower lip that is present with class II patients. According to Flores-Mir et al.<sup>6</sup> both lips are supported far more by the upper incisors and this is why protrusion of the lower incisors occurs during the therapy and is not followed by the expected protrusion of the lower lip. This has been also supported by other authors<sup>22-26</sup>. Thus, it can be concluded that the relation of soft tissues changes and skeletal structures is not linear, but a very complex one<sup>29</sup>.

Even though the therapy caused the forward movement of the chin, its surface enclosed by the reference space was not reduced due to the simultaneous change in the slope of the Juanita line. The surface occupied by the nose within the reference field was increased due to Juanita line rotation.

The change in the slope of the Juanita and E lines caused changes in the proportions of the filled and free spaces of the soft tissue profiles. The presence of the free space was greater after the therapy, indicating improved aesthetics of the patient's profile. A remarkable improvement in the appearance of patient's profile was cited previously by other authors<sup>11, 13, 20</sup>. Even though Herbst appliance therapy could be followed by statistically significant changes in the soft tissues their clinical visibility is debateable. In order to conduct a detailed evaluation of the aesthetic effects of the therapy, an analysis of the appearance of the patient during different facial movements (*eg* smiling, different mimics, etc.) and during speech has to be performed. The use of stereophotogrametry and laser scans of the surface of the

face could overcome the limitations of the use of photogs for this purpose<sup>6</sup>. The use of the E-line during analysis of the soft tissue profile requires caution as simultaneous changes in soft tissue pogonion and pronasal occur and both have an effect on the appearance of the lips<sup>6</sup>.

Skeletal, dental and soft-tissue changes induced by the Jasper Jumper appliance in late adolescence, that uses the E line as a reference line, were not found to produce significant antero-posterior changes of the upper lip<sup>30</sup>. However, statistically significant protrusion of the lower lip was noted which is contrary to the findings observed in the current study.

## Conclusion

Based on the obtained results, soft tissue treatment effects of the Herbst appliance are: a reduction of the relative surface of the upper lip in both genders; a slight increase in the relative surface of the lower lip; a reduction of the relative surface occupied by the chin; a significant improvement of the profile appearance; a consequence of the upper incisors retrusion, lower incisor protrusion and forward movement of the lower jaw.

The extent of soft tissue changes that occur on its denoalveolar and skeletal support is a complex issue.

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